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THE EFFECTS OF AGGREGATION AND DISAGGREGATION ON PARTICLE SIZE DISTRIBUTIONS AND WATER CLARITY IN THE COASTAL OCEAN

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LONG-TERM GOAL

The long-term goal of this research is to develop tools to quantitatively predict the effect of fine siliciclastics on water clarity in the coastal ocean. Scattering of light by particles depends on sediment concentration and the size distribution of material in suspension. Particle size distributions in coastal waters are dynamic because high concentrations of suspended sediment in coastal waters favor frequent encounter between particles. These encounters lead to the formation of large macroaggregate particles, or flocs, with diameters greater than 0.5 mm. While aggregation modifies the size distribution by building larger particles, variable and energetic turbulence in coastal waters can modify the size distribution by disrupting aggregates. Predictive knowledge of scattering depends on understanding of the conditions under which aggregation and turbulence-induced disaggregation alter the size distribution and of the form of the size distribution that these processes combine to produce.

SCIENTIFIC OBJECTIVES

This research has three primary objectives. The first is to observe spatial and temporal variability in macroaggregate size distributions in situ in the bottom boundary layer (BBL) at the Coastal Mixing and Optics field site. The second is to relate observed size distributions to small particle size distributions, turbulent kinetic energy (tke), and optical properties in the BBL. The third is to extend BBL aggregation models to conditions of unsteady flow.

APPROACH

Time-series photographs of macroaggregates have been taken with a bottom-tripod-mounted FLOC camera on the continental shelf in the mid-Atlantic Bight during ONR's Coastal Mix- ing and Optics deployment. Data synthesis involves comparison of in situ macroaggregate size distributions with small particle size distributions generated with an in-situ, laser particle sizer (LISST) deployed on the same tripod as the camera (Agrawal, Sequoia), with turbu- lent kinetic energy dissipation rate measurements made on a nearby tripod (Trowbridge, WHOI), and with optical properties monitored on the same tripod as the camera (Dickey, UCSB). Numerical modelling involves collaboration with Pat Wiberg (UVa) to incorporate new methods for treating aggregation and disaggregation into conventional finite-difference approaches to solving advection-diffusion-reaction equations.

WORK COMPLETED

During the CMO field effort, 250 photos were collected. Methods have been developed for analyzing size distributions, archiving data, and presenting data interactively on the world wide web. A manuscript is in preparation describing destruction of macroaggregates during storms. In collaboration James Syvitski, his FLOC camera was deployed in Alaska in profiling and moored mode. Overall, 980 images from three fjords were collected in May, 1995. Excess-density-versus-diameter relationships have been produced from data collected in the moored deployment. All other images have been analyzed. Collaboration with Pat Wiberg on incorporating aggregation into her sediment transport model began during the summer of 1996.

RESULTS

Data on macroaggregate size distributions, waves, and currents indicate that turbulence does not strongly influence macroaggregate size when tke is low to moderate, but that macroag- gregates are destroyed under energetic forcing. This result suggests that forces other than turbulence, namely those applied to macroaggregates during sinking, limit macroaggregate size when tke is low to moderate. This hypothesis explains why measured macroaggregate settling velocities across diverse environments, including the measurements made in Alaskan fjords, are so uniform.

IMPACT/APPLICATION

Fine sediment suspensions can likely be treated as a two-state system. When tke is low to moderate, the majority of suspended mass is contained in macroaggregates that sink at speeds of 1 mm s the fate of destroyed macroaggregates.

TRANSITIONS

The camera technology developed in this study has been adopted in part by Syvitski for contruction of a DURIP-funded floc camera.

RELATED PROJECTS

With NSERC (Canadian) funding, the spectral response of optical backscatter to particle size distribution is being explored. Collaborator is Jon Grant (Dalhousie).

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Milligan, T. G. and P. S. Hill (in press). Laboratory assessment of the relative importance of turbulence, particle composition, and concentration in limiting maximal floc size, Journal of Sea Research. Hill, P. S., J. P. Syvitski, E. A. Cowan, and R. D. Powell (in press). In situ observations of floc settling velocities in Glacier Bay, Alaska, Marine Geology. Hill, P. S. and I. N. McCave. Suspended particle transport in benthic boundary layers, submitted for consideration as a chapter in The benthic boundary layer: Transport processes and biogeochemistry, edited by B. Boudreau and B. B. Jørgensen.